WARWICK
ECONOMICS

CRETA
Centre for Research in Economic Theory and its Applications

Discussion Paper Series

Externalities and financial crisis – enough to cause collapse?

Marcus Miller and Lei Zhang

(This paper also appears as
Warwick Economics Research Papers series No: 1207)

July 2019 No: 51

CRETA
Centre for Research in Economic Theory and its Applications
Department of Economics
University of Warwick, Coventry,
CV4 7AL, United Kingdom

warwick.ac.uk/fac/soc/economics/research/centres/creta/papers

Externalities and financial crisis – enough to cause collapse?

Marcus Miller and Lei Zhang[1]

University of Warwick and CEPR Sichuan University

July 2019

Abstract

After the boom in US subprime lending came the bust - with a run on US shadow banks. The magnitude of boom and bust were, it seems, amplified by two significant externalities triggered by aggregate shocks: the endogeneity of bank *equity* due to mark-to-market accounting and of bank *liquidity* due to 'fire-sales' of securitised assets. We show how adding a systemic 'bank run' to the canonical model of Adrian and Shin allows for a tractable analytical treatment - including the counterfactual of complete collapse that forces the Treasury and the Fed to intervene.

Keywords: pecuniary externalities, bank runs, illiquidity, Lender of Last Resort, cross-border banking

JEL Classification: G01, G11, G24

When the crisis struck, I'm sure I wasn't the only economist to yell at oneself, 'Diamond–Dybvig, you idiot!' Paul Krugman (2018, p. 158)

1. Introduction

How is it that the financial crisis of 2008 caught both bank regulators and bankers themselves so badly off guard? The factor explored in this paper is the role played by externalities. For, broadly speaking, financial stability and market liquidity may be regarded as public goods that benefit all players in the financial system: sustaining them, however, requires restraint on the part of participants. Private incentives to act otherwise, by amplifying boom and bust, can generate negative externalities, possibly ending in crisis.

In tracing the history of the Basel Committee of Banking Supervision, Charles Goodhart (2011) criticises the regulators for their belief that making *individual* banks safe - by Value-at-Risk rules on equity (VaRs) in particular – would ensure a safe and secure banking system world-wide. That this regulatory mantra ignored systemic risk was neatly demonstrated by Shin (2010) and Adrian and Shin (2011). In their canonical model of investment banking[2], pursuing financial stability by imposing Value-at-Risk rules on equity for individual banks

[1] The authors are grateful to Bruce Gaston, Morgan Kelly, David Storey and members of the ESRC Instability Hub, Nicholas Beale in particular, for comments and suggestions; and to Martin Rohar for his technical support funded by the Warwick Internship for Scheme for Economists. Responsibility for errors remains with us.

[2] which, for brevity, we refer to simply as the Shin model in what follows.

suffers from the Fallacy of Composition: it ignores the fact that, with marking-to-market in the face of aggregate shocks, bank equity becomes endogenous – rising with good news on asset-backed securities and falling on bad. Consequently, a system subject to tight VaR regulation is unstable insofar as it amplifies the effect of aggregate shocks to the quality of assets held by these banks. Regulators, it seems, had ignored an important 'pecuniary externality' – what happens when asset price changes meet micro-prudential balance sheet rules[3].

Ignoring systemic risk not only distorts regulation: it also leads private agents to under-estimate the value of liquid reserves[4]. Bankers who reckoned that holding 'marketable' assets relieved them of the need to hold liquid reserves also suffered from a Fallacy of Composition: for, in the face of aggregate shocks, the vaunted marketability of securitised assets can vanish in collective 'fire sales'.

Ben Bernanke (2018a) succinctly describes how financial panic can lead to a drying up of funding and to asset fire sales:

> Before the crisis, investors (mostly institutional) were happy to provide wholesale funding, even though it was not government insured, because such assets were liquid and perceived to be quite safe. Banks and other intermediaries liked the low cost of wholesale funding and the fact that it appealed to a wide class of investors. Panics emerge when bad news leads investors to believe that the "safe" short-term assets they have been holding may not, in fact, be entirely safe. If the news is bad enough, investors will pull back from funding banks and other intermediaries, refusing to roll over their short-term funds as they mature. As intermediaries lose funding, they may be forced to sell existing loans and to stop making new ones.

That many of those involved were not American banks added to the problem of illiquidity, for, according to Tooze (2018, p. 206):

> If the Fed did not act, what threatened was a transatlantic balance sheet avalanche, with the Europeans running down their lending in the United States and selling off their dollar portfolios in a dangerous fire sale. It was to hold those portfolios of dollar-denominated assets in place that from the end of 2007 the Fed began to provide

[3] As Davila and Korinek (2017) observe: "Intuitively, when agents are subject to a binding constraint that depends on aggregate variables, a planner internalizes that she can modify allocations to relax financial constraints. For example, the planner may reduce fire sales to raise the value of capital assets that serve as collateral, which raises the borrowing capacity of constrained agents." But market players don't internalize the price effects of collective action.

[4] Allen and Gale (2007, Chapter 5) indicate how individual agents undervalue the value of holding liquid assets in circumstances where markets are incomplete; and Korinek (2009) discusses the private under-provision of liquidity where there is systemic risk.

dollar liquidity in unprecedented abundance not only to the American but to the entire global financial system, and above all to Europe.

There is a considerable literature examining the role of Network externalities in propagating disturbances in financial systems, Allen and Gale (2000) and Gai et al.(2011), for example. These are not the subject of this paper, however, which is much closer in spirit to Gertler and Kiyotaki (2015) who focus on Strategic Complementarity and Fire Sales.[5] Their explicit aim, 'to develop a simple macroeconomic model of banking instability that features both financial accelerator effects and bank runs', is executed in elegant fashion with calibrated examples; and is developed further in subsequent papers – distinguishing explicitly between commercial and shadow banks in Gertler et al. (2016) and making the stock of capital endogenous with the aid of a New Keynesian model, Gertler et al. (2017).

A striking feature of their approach, however, is that 'banks in the model are completely unregulated'! (To confirm, the reader may refer to Gertler and Kiyotaki, 2015 p.2016.) Since banks are assumed to be more efficient than households in managing capital resources this poses two puzzles: first what prevents them from managing all the assets in the economy? and second what prevents them from cheating (specifically by stealing some of the profits)? Assuming that 'rational depositors will not lend funds to the banker if he has an incentive to cheat', the answers they provide (in reverse order) are : *self-regulation* will be sufficient to check moral hazard in banking[6]; and the equity buffer ('skin in the game') required to do this[7] acts as a '*financial market friction'* which limits the size of the banking sector. As for hedge funds, therefore, it is not regulatory requirements that limit leverage, but the necessity for managers to reassure creditors of their common interest in promoting successful investments.

By contrast, we follow the approach taken by Adrian and Shin where risk-neutral bankers are subject to *explicit regulation* designed to ensure that their own equity covers the downside risk. So it is not self-regulation but capital requirements imposed by regulators that limit the capacity of risk neutral banks to hold risk assets. In this setting, we provide a tractable method for analysing the Strategic Complementarity in the response of Investment Banks to news on the quality of risk assets; and the impact of Fire Sales when creditors withdraw funds in response to bad news. With calibration, this allows one to consider the counter-factual of what might have happened in the recent crisis without US Fed and Treasury intervention.

---

[5] To use the terminology of De Nicolo et al. (2012) in their overview of "externalities and macro-prudential policy".

[6] As bankers who steal will effectively lose their franchise one period later, any financial arrangement between the bank and its depositors has to satisfy the incentive constraint that the value the manager can amass by stealing must be less than the franchise value of running the bank without stealing.

[7] Put at 10% of the balance sheet in their numerical example.

The paper proceeds as follows. In section 2, after recapitulating key features of the canonical model of Investment Banking to be used, the focus in is on what the regulators ignored, namely the pecuniary externality[8] that amplifies the impact of aggregate shocks – like 'good news' about the riskiness of assets being traded.

In section 3 the focus is on what the bankers had not anticipated – the evaporation of liquidity when widespread funding withdrawal leads to asset sales by highly-leveraged actors. Marketability in normal times, they discovered, is no guarantee of liquidity in such circumstances. Absent a Lender of Last Resort, these 'fire-sales' threaten insolvency – much like the early recall of illiquid bank loans in the bank run model of Diamond and Dybvig (1983) that Krugman refers to in the epigraph above.

Finally, the onset of systemic crisis can be explored, where 'bad news' on bank assets triggers a withdrawal of funding and causes insolvency via both equity and 'fire sale' externalities. With the qualification that - given the forthright intervention by Treasury and the Fed - this is a counter-factual exercise, a calibration is provided in Section 4. Though undeniably sparse and simplified, the tractability of the model allows one to see how externalities can precipitate financial collapse[9].

In Conclusion, the implications of taking such externalities into account, both for theory and policy, are briefly summarized – followed by an important caveat. We refer to evidence that the subprime market was in fact plagued by cheating *that was not checked* – the manipulation of capital ratios and the mis-representation asset quality in particular. This suggests the need to complement the role of externalities by what Akerlof and Shiller(2015) call 'the economics of manipulation and deception'.

2. Pecuniary externalities and amplification

2.1 The canonical Shin model

There are two assets: (1) a riskless bond with its rate of return normalized to 0; and (2) a risky asset with random payoff Q, uniformly distributed over [q − z, q + z] where q > 0, with moments denoted by: $E[Q] = q$ and $Var(Q) = \frac{z^2}{3}$. Both types of investors are endowed with initial equity denoted *e*. Investors' portfolio payoff (end of period wealth) is $W \equiv Qy + (e - py)$, where *y* represents the quantity of the risky asset holdings and *p* is the price of the risky asset.

---

[8] Such 'pecuniary externalities', were first analysed by Kiyotaki and Moore (1997) to provide a variant of the 'financial accelerator' of Bernanke and Gertler (1989).

[9] We do not, however, go further to look at the linkage between credit disruption and the real sector, a topic analysed numerically using a DSGE model by Gertler et al. (2017) and in considerably greater detail by Bernanke (2018b).

Unleveraged 'passive' investors

As they do not borrow to finance their investments, risk-averse investors are categorised as 'passive'. Their 'mean-variance' preferences are described by $U(W) \equiv E(W) - \frac{1}{2\tau}\sigma_W^2$, where τ represents their risk tolerance and, since their portfolios comprise of riskless bonds and holdings of the risky asset, denoted *x*, the portfolio variance is $\sigma_W^2 = \frac{x^2z^2}{3}$. The risk averse investors' optimization thus becomes: $\max_y \left(qx + (e - px) - \frac{x^2z^2}{6\tau}\right)$; so for $q > p$ the demand function of passive investors is:

(1) $$x = \frac{3\tau}{z^2}(q - p)$$ *Risk-averse demand*

where $\eta = 3\tau/z^2$.

Note that, because of the assumption on mean-variance preferences, the demand for the risky asset by passive investors is independent of their wealth and depends solely on the risk premium.

Leveraged, 'active' investors: referred to as Investment Banks

Risk-neutral 'active' investors use leverage – issuing debt to finance their investments in risky assets, denoted *y,* subject to a VaR constraint. For convenience, we refer to them collectively as Investment Banks (IBs) although commercial banks, Government Sponsored Enterprises and hedge funds are also included, Shin (2010, p.153, Table 9.1). Specifically, the optimization of these active investors is described as:

$$\max_y E(W) \qquad s.t. \qquad VaR = (p - q + z)y \leq e \text{ where } E(W) = (q - p)y + e$$

where the VaR constraint implies that borrowing is no greater than can be financed with the worst realized payoff on the asset, $py - e \leq (q - z)y$. Since $E(W)$ is linear in *y*, then for $q > p$, so long as the VaR constraint is binding and there is no funding constraint, the demand for risky assets by investment banks becomes:

(2) $$y = \frac{e}{(z-(q-p)}$$ *Risk-neutral demand subject to VaR*

For $q > p$ and fixed aggregate supply of risky assets, normalised at 1, the market clearing condition is:

(3) $$y + x = 1$$ *Market clearing*

Note that leverage is defined as $\lambda = \frac{py}{e}$.

2.2 Baseline: initial equilibrium

Equilibrium may be found by substituting the demand functions into the equation for market clearing and, for convenience, using the notation $\pi = q - p$ (which we refer to as the risk premium[10]) to yield:

(4) $\eta\pi^2 - (1 + \eta z)\pi + z = (\eta\pi - 1)(\pi - z) = g(\pi; z) = g(q - p; z) = e_0$

a quadratic polynomial with roots $\pi = z$ and $\pi = \eta^{-1}$.

This quadratic is plotted in Figure 1, with price, p, on the vertical axis and Investment Bank equity e on the horizontal, and the risk premium π measured as the shortfall of p below q in the figure. As the function $g(q - p; z)$ indicates, higher levels of initial IB equity will be associated with higher market clearing prices of risk assets to an upper limit of q. At the point labelled H, where the equity base of investment banking is sufficient to cover the downside on all risk assets, i.e. $e = z$, risk averse investors play no part; so $p = q$ and there is no risk premium.

At prices below the expected payoff, q, however, positive risk premia tempt risk averse investors to enter the market. For convenience (and broadly in line with the parameter restriction suggested by Shin, 2010, p.36), we start with the special case where both roots of the quadratic coincide, so $g(q - p; z)$ is tangent to the vertical axis where $q - p = \pi = z = \eta^{-1}$. Hence, at the point labelled L, risk averse investors would be willing to take all risk assets onto their balance sheets.

For a given level of initial IB equity $z > e_0 > 0$,the price of risk assets will lie between q and $q - z$, as shown at point A in the Figure. It is assumed that IBs can borrow as much necessary to maximise their asset holdings subject to the VaR constraint, implying that $e_0 = y_0\,(z - q - p_0)$ at A. How Good News on asset quality affects asset valuation and IB equity is considered next.

[10] This is not strictly correct, however, as the risk premium properly defined is $(q - p)/p$. Note that Shin (2010) uses the same symbol to denote $(q - p)/q$.

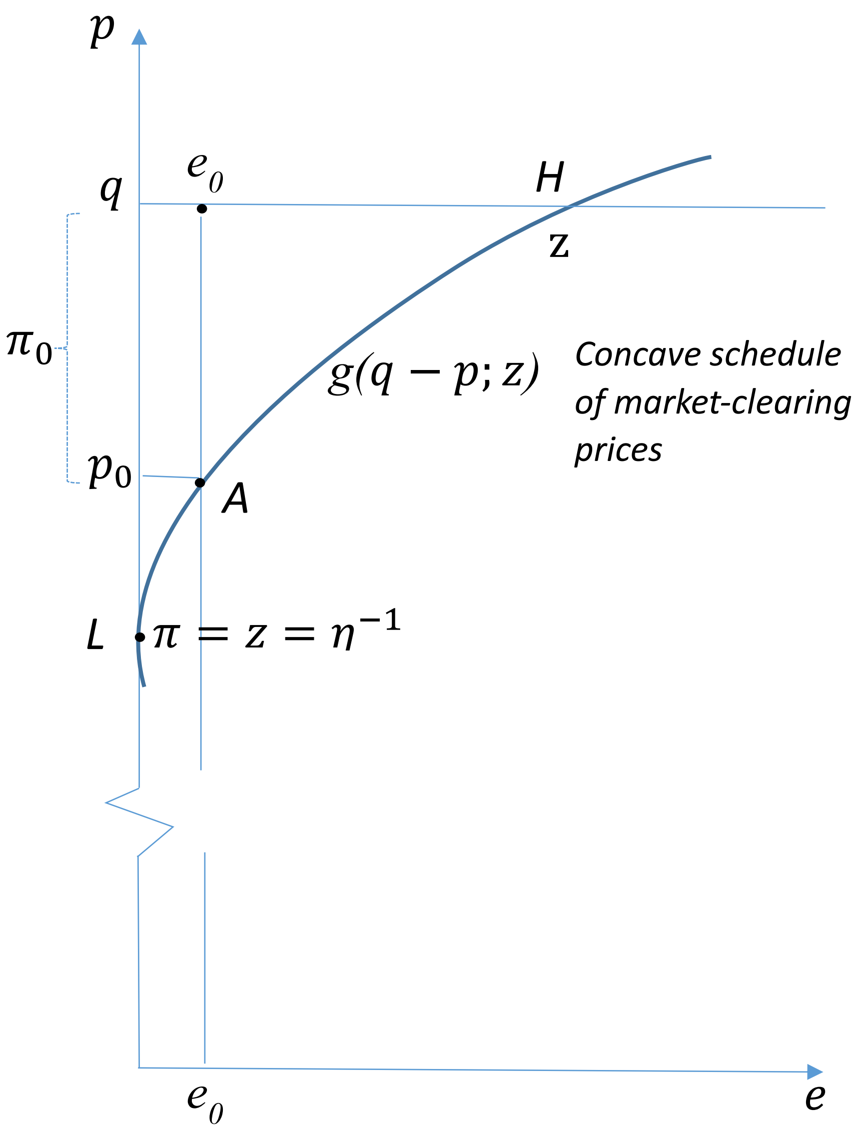


Figure 1. The market clearing price of risk assets, given initial IB equity

2.3 How the effect of Good News gets amplified

The Good News we refer to is a widely-perceived improvement in the quality of risk assets, as for example when CRAs give high ratings to subprime assets, Akerlof and Shiller (2015, Chapter 2), Financial Crisis Inquiry Commission (2011, Chapter 10). This could be a rise in the mean return, q; or a reduction in the maximum risk to $\underline{z}$. Here we focus on the reduction of risk.

Before solving for the impact and equilibrium effects of such 'news' in terms of the market-clearing schedule $g(q-p;z)$, it may be helpful to indicate these effects as in Figure 2, where the initial demands of each sector taken separately are plotted as a function of asset price and IB equity of e_0. Given a fixed supply, the demand of passive investors, measured from the RHS and given by $\eta\pi = \eta(q-p)$, increases as the price falls below q; while the demand for active investors, measured from the LHS, is given by $y = e_0/(z-\pi)$ and shown as a segment of the rectangular hyperbola passing through e_0/z (when the risk premium is zero) and tending asymptotically to *q-z* . Initial equilibrium is at A.

On *impact*, the reduction of perceived risk increases demand by both sectors. For passive investors, the fall in downside risk (from z to $\underline{z}$) makes risk assets more attractive, as indicated by the increase in Passive Demand shown in the figure. The demand schedule for active investors subject to a binding VaR constraint shifts to the right (from e_0/z to $e_0/\underline{z}$ at the top of the figure) as the unit risk falls; and it flattens out as the lower asymptote moves up to $q-\underline{z}$. With no marking of this price increase to market, equilibrium will move from A to B as shown, with a substantial change in the price and the risk premium but not much trading of assets[11].

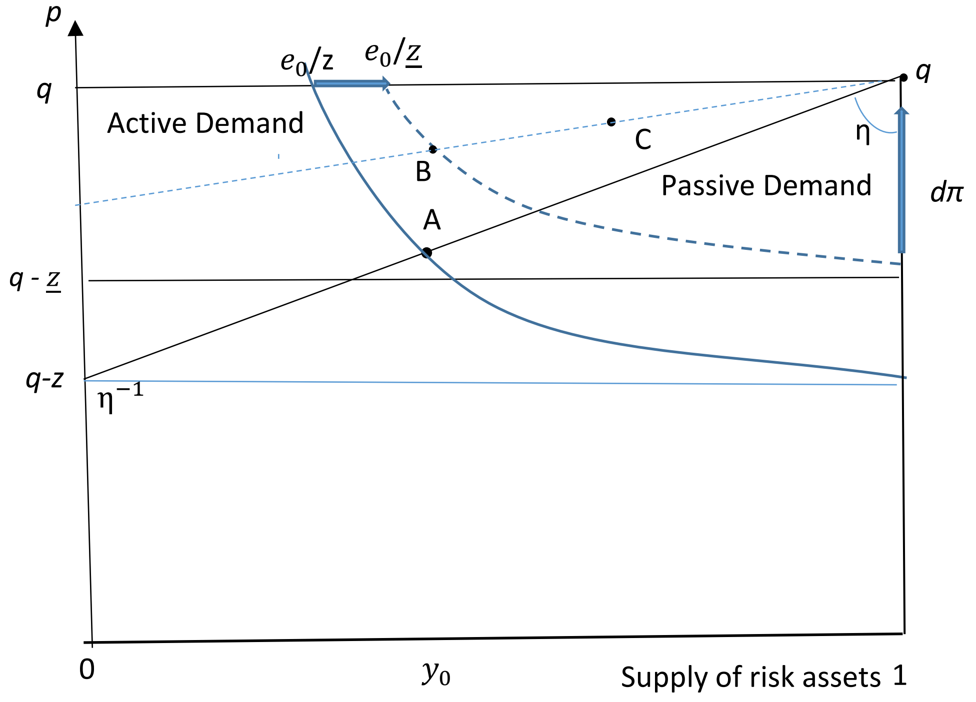


Figure 2. Demand, Supply and Market-clearing

When their assets are marked-to-market at these higher prices, however, the increase in IB equity will – consistent with the VaR constraint - allow for increased asset holding. These

[11] As illustrated in the calibration below.

endogenous adjustments of bank equity will *amplify* the effect of Good News, with Investment Banks expanding their market share so equilibrium shifts along the demand curve for passive investors to a point like C. (Whether or not the leverage of the banks rises or falls depends on how the balance sheet expansion compares with the equity increase.)

Turning to aggregate market clearing, the *impact* effect of reducing the measure of downside risk on the risk premium and on market prices is found by replacing z in (4) by $\underline{z}$ to give:

(4a) $$\eta_1\pi^2 - (1+\eta_1\underline{z})\pi + \underline{z} = (\eta_1\pi - 1)(\pi - \underline{z}) = g(\pi;\underline{z}) = g(q-p;\underline{z}) = e_0$$

where $\eta_1 = \frac{3\tau}{\underline{z}^2}$ as the demand by passive agents is also affected since the news is common knowledge.

How this affects the price of risk assets is illustrated in Figure 3, which focuses on asset prices close to q , with the value of equity measured along the horizontal as before. As shown, the reduction of downside risk **raises the schedule indicating market-clearing prices** from $g(q-p;z)$ to the solid line labelled $g(q-p;\underline{z})$. So the *impact effect* on market price **without marking to market** is indicated by the upward shift from A to B as measured at the initial level of equity e_0. (Note that, with the fall in downside risk, $\eta_1^{-1} < \underline{z}$, i.e. the root associated with nonbanks holding all risk assets is now smaller than the measure of downside risk.)

The 'amplification' effect that arises when assets are 'marked to market' is indicated by the movement from B to point C, where the polynomial intersects the schedule labelled MM measuring the impact of rising prices on IB equity. Here we follow the methodology of Shin (2010) who uses initial IB holdings as the benchmark to which price adjustments are applied. Solving for equilibrium with endogenous equity involves

$$g(q-p;\underline{z}) = e = y_0\,(p-(q-z)) \qquad (5)$$

gives equilibrium at C, where the increase in the equity value as balance sheets are marked to market is measured as $y_0\,(p_1 - p_0)$. (One could think of this equilibrium as the limit of a series of equity adjustments, with the first step shown in the figure.)

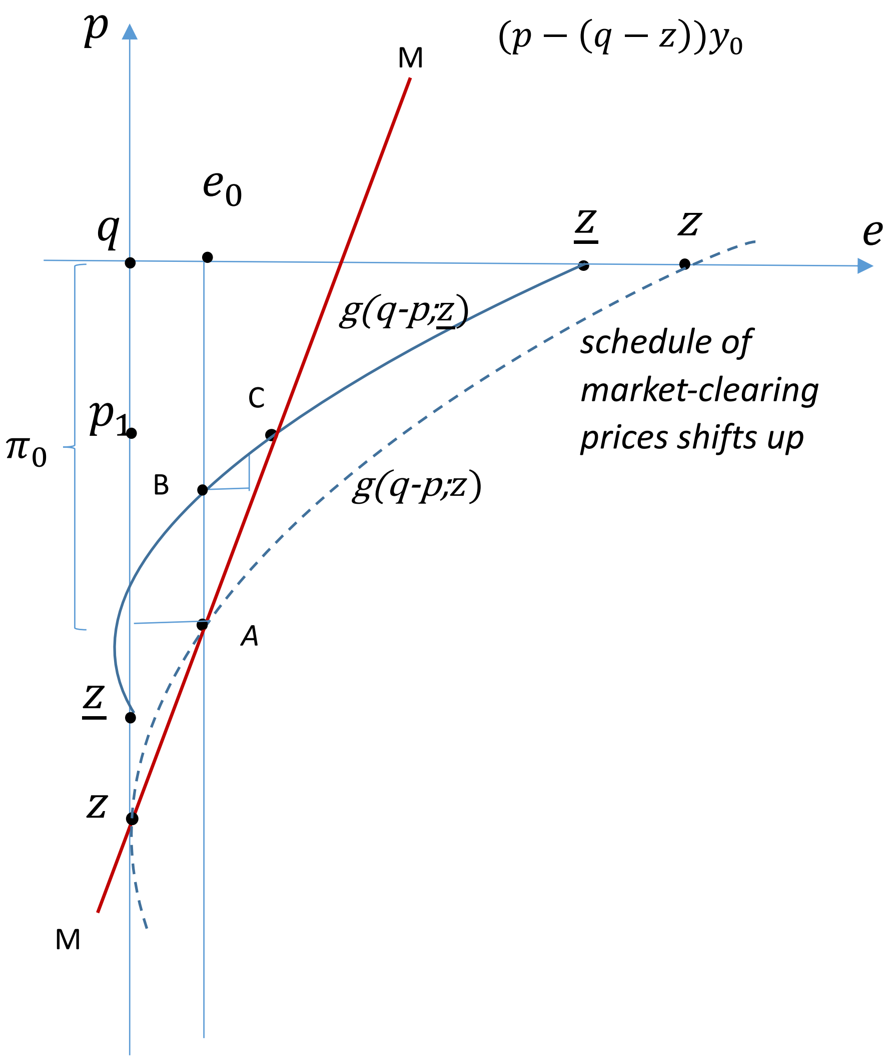


Figure 3 Good News on asset quality increases market valuation; and bank equity

In the calibration reported below, a reduction of perceived risk has a substantial effect on bank equity, which almost doubles in the market-clearing equilibrium. Thus, despite the strict application of VaR rules, there is a substantial rise in the market-clearing price and the share of the leveraged sector as the effect of rising asset prices on their equity allows Investment Banks to expand their balance sheets – a pecuniary externality seemingly ignored by the Basel regulators.

3. How Bad News can threaten Insolvency: especially when Funds are withdrawn

Thus far we have assumed that, in order to expand their balance sheets as far as VaR rules permit, Investment Banks can always obtain - at low cost - the funding needed, typically in the form of repos[12]. But what if such funding is withdrawn in a 'silent' run[13]?

Absent liquidity reserves, assets will need to be sold to meet the withdrawal of funding. By seeking to reduce assets and liabilities in tandem, investment banks will be acting 'as if' they are targeting a higher capital ratio - albeit involuntarily. *If many banks do this at the same time, however, asset prices will fall in the 'fire-sale' of involuntary deleveraging and bank equity will be reduced both by trading losses on sales and the marking down of assets retained.*

> In Annex A it is shown that a system-wide 'bank run' (involving a loss of funding by the fraction ω) can be analysed by banks adjusting their portfolios 'as if' they are planning to hold capital for increased downside risk – as if their portfolios are determined not by equation (2) above but by

(8) $y = \frac{e_0}{(z^{\omega} - \pi)}$

where $z^{\omega} = (1 - \omega)z + \omega q$.

How to model the onset of financial crisis where, as Bernanke describes it, there is Bad News about the assets in bank portfolios and this triggers a withdrawal of funding?

As indicated in Figure 4, we do this in two stages. First, on the assumption that the news is of an increase in asset risk, there is the impact effect of a rise in the downside risk parameter which - given the steep rise in volatility seen during the crisis[14] - we assume will 'overshoot' the starting value z. Jon Danielsson (2029, p.263) supports the idea that people over-reacted:

> Before 2008, everybody believed that the banks knew what they were doing, that they could value asseis correctly and had accurate risk assessments. When things started going wrong, everybody's opinion changed by 180 degrees, and everybody thought that al evaluations and all risk asssessments were wrong. Typical in crises.

This will of course lead to an immediate reduction of aggregate demand for risk assets and and a fall in their price.

[12] where the 'borrower' sells securities to the 'lender' with a commitment to repurchase at a future date at a specified price.

[13] so-called because – rather than depositors running to withdraw their funds - repos are simply not rolled over.

[14] See Adrian and Shin (2014), p.381.

Second we add a systemic Bank Run. So, as the news leads to a funding withdrawal from IBs, there will be asset firesales, leading to added downward pressure on prices. The fall in equity, when trading losses on such sales are added to the write-down as remaining assets are marked to market, may indeed pose a threat of immediate insolvency, as indicated in the calibration below.

To compute these shifts numerically we first replace $\underline{z}$ by $\overline{z}$ in (4a) to give

(4b) $\eta_2 \eta \pi^2 - (1 + \eta_2 \overline{z})\pi + \overline{z} = (\eta_2 \pi - 1)(\pi - \overline{z}) = g(\pi; \overline{z}) = g(q-p; \overline{z}) = e_1$

where $\eta_2 = \frac{3\tau}{\overline{z}^2}$ as the news is common knowledge; and e_1 denotes equity as measured at the peak of the preceding boom. (Note that, the root ${\eta_2}^{-1}$ is now greater than the increased measure of downside risk, $\overline{z} > z$.)

This will **lower the schedule giving market-clearing prices**, from $g(q-p; \underline{z})$ to $g(q-p; \overline{z})$, shown as a solid line in Figure 4. For given equity e_1 this downward shift will lead to fall in prices from C to D. Thus the *impact* of Bad News on the market clearing price - without marking to market – is found by solving for $g(q-p;\ \overline{z}) = e_1$.

How to incorporate the effect of a run? As discussed in Annex A, this will involve replacing $\overline{z}$ by z^w for the banks, while leaving η_2 unchanged for passive investors, i.e. solving for $\eta_2(q-p)^2 - (1 + \eta_2 z^w)(q-p) + z^w) = e_1$, where $\eta_2 = \frac{3\tau}{\overline{z}^2}$. The effect of this on asset prices as the size of the run ω increases is **indicated by the arrow running downward** from D to R in Figure 4.

When the impact of these falling prices is taken on the balance sheet this may well imply immediate insolvency, as indicated by negative values on the endogenous equity schedule $e = \left(p - (q - \underline{z})\right) y_1$. This will be true if the run R takes the price of assets below q- $\underline{z}$, the lowest level that the IB equity base can cover. For in that case trading losses and marking to market using the endogenous equity schedule shown as $\left(p - (q - \underline{z})\right) y_1$, i.e. moving horizontally from R to the equity valuation schedule in the Figure, will lead to a negative value for equity, as illustrated in the calibration below.

Is this, perhaps, overly dramatic? After all only one US investment bank was actually liquidated in the crisis! Our illustration is, however, an avowedly counter-factual exercise where no account is taken of the spectacular rescue operations mounted by the Fed and the Treasury to avoid wholesale liquidations. The US Financial Crisis Inquiry Commission (2011, p. 386) put it bluntly:

> The Commission concludes that, as massive losses spread throughout the financial system in the fall of 2008, many institutions failed, or would have failed but for government bailouts. … the country [was left] with stark and painful alternatives – either risk the total collapse of our financial system, or spend trillions of taxpayer dollars to stabilize the system and prevent catastrophic damage to the economy.

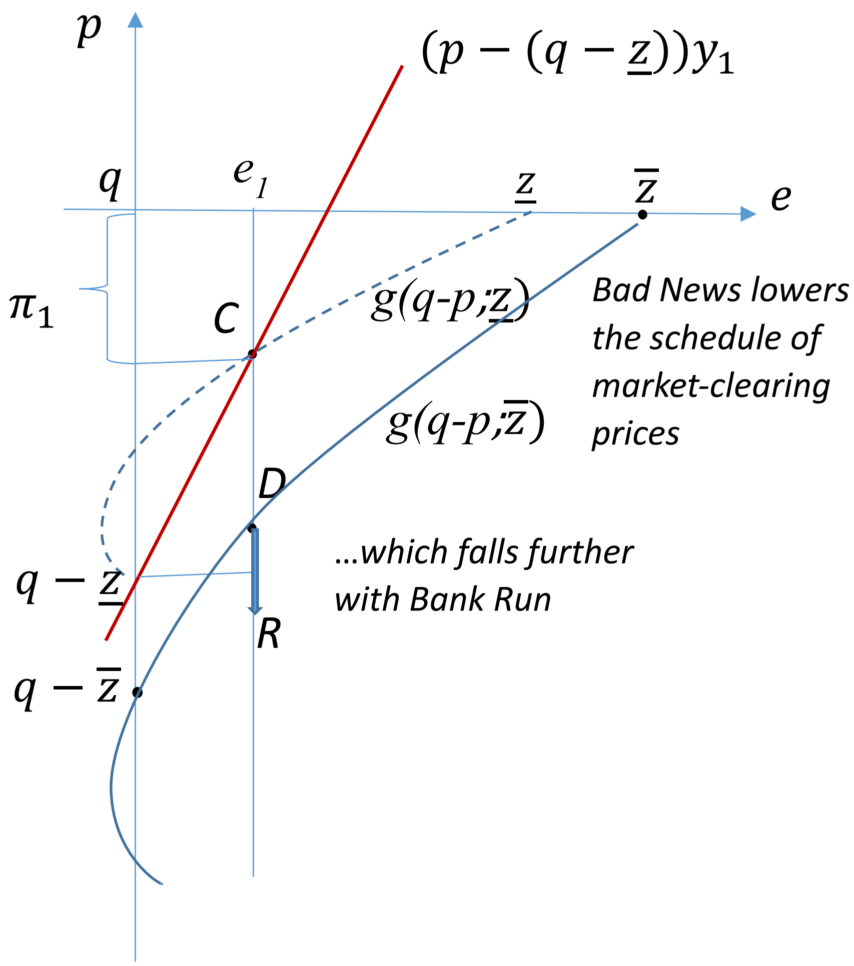


Figure 4 Bad News and a 'Bank Run' leading to prompt insolvency

Capital injections by the Treasury, using TARP funds of $70b for the four investment banks remaining in business after Lehman went into liquidation[15], constituted more than half the equity they reported for end-2007, for example (Miller *et al.*, 2018, p.103). In terms of liquidity support, those same banks, with balance sheet value of about $3.5tr at the end of 2007 (and leverage averaging 30), are on record as having utilised the Fed's primary dealer overnight facility to the tune of over $4tr in the ensuing crisis (Tooze, 2018, p.216). As Blinder (2013, p.124) indicates, two of them (Goldman Sachs and Morgan Stanley) registered as Bank Holding Companies for the purpose, after the other two had been taken over by commercial banks.

[15] Namely Goldman Sachs, Merrill Lynch, Morgan Stanley and Bear Sterns

In the opinion of the historian Adam Tooze (2018, p.9):

> Never before, not even in the 1930s, had such a large and interconnected system come so close to total implosion. But once the scale of the risk became evident, the US authorities scrambled. … not only did the Europeans and Americans bail out their ailing banks at a national level. The US Federal Reserve … established itself as liquidity provider of last resort to the global banking system.

4. A calibrated illustration

To illustrate, we present a calibration to show first how 'pecuniary externalities' amplify a boom triggered by Good News; and then how banks could – absent intervention - suffer from prompt insolvency in the face of Bad News combined with a Bank Run.

Table 1: Parameters values used in calibration[16]

Variable	Name	Description	Value
z	downside risk	z=σ$\sqrt{3}$	0.08
σ	monthly standard deviation of stock index	Converted from annual rate σ=0.16/ $\sqrt{12}$	0.046
τ	Risk tolerance of patient investors	z/3	0.08/3
q	Expected one month payoff on risk assets	Converted from annual return (1.08)^(1/12)	1.00643
e_0	Initial IB equity	Chosen to give leveraged banks approx. 65 % of assets at peak	0.015
$\underline{z}$	Good News	z – 0.02	0.06
$\overline{\underline{z}}$	Bad News	z + 0.01	0.09
λ	leverage	Value of assets/equity	
ω	Bank run	Fractional loss of funding	0.1627

Using the parameter values indicated in Table 1 produces the results in Table 2 below.

[16] The post-war mean value-weighted NYSE is about 8% over the T-bill rate, with a standard deviation of about 16% (Cochrane, 2001, p. 456).

Table 2 Calibration results

		1	2	3	4	5
		Initial Equilibrium	Impact effect of 'Good News' (lower risk)	Equilibrium effect of 'Good News' with mark to market	Impact effect of 'Bad News' (risk at crisis level)	Impact effect of Bad News plus Bank Run
1	Max downside risk	0.08	0.06	0.06	0.09	0.09
2	Risk premium	0.0454	0.0255	0.0165	0.0426	0.1013
3	IB Holdings	0.4330	0.4343	0.6323	0.5794	0
4	Market Price	(0. 9610)	(0.9809)	(0.9899)	(0.9638)	(0.9051)
	Aggregated IB balance sheet					
5	Asset value	(0.4161)	(0.4260)	(0.6259)	(0.5584)	0
6	Debt	(0.4011)	(0.4110)	(0.5984)	(0.5309)	0
7	Equity	0.015	0.015	0.0275	0.0275	0
8	Bank Run					0.1625
9	Leverage	27.7438	28.3998	22.7802	20.3265	n.a.

In the **initial equilibrium** shown in the first column, the IBs hold about 43% of risk assets, see row 3. With a market-clearing price of 0.96, this implies assets worth 0.4161 on the aggregate balance sheet, funded by borrowing and by 0.15 of own equity, implying leverage of about 27, see rows 4,5, 7 and 8.   The risk premium needed to clear the market, namely 0.045 (row 2), is just over half maximum downside risk of 0.08.

The **impact effect of Good News** (which narrows the maximum downside risk of returns by a quarter) leads to a rise in the market price, and a halving of the risk premium. But with equity kept at its original value, there is little asset acquisition by IBs, whose leverage rises somewhat to over 28, see last entry in column 2.

Marking capital gains to market, however, leads to a boom with a **Good News equilibrium** in column 3 where the equity of the banks has almost doubled and their share of assets has risen to 65%. That their equity has risen faster than the value of assets implies that leverage has fallen somewhat, to about 23.

On impact, Bad News (that raises the maximum downside risk to 0.09, somewhat above its initial level) triggers substantial unloading of assets by banks, whose leverage falls to 20; and a substantial rise in the risk premium is required so as to get non-leveraged investors to take up these assets, see Column 4.

Finally, as indicated in the last column, **adding a systemic bank run**[17] of less than 20% will – with mark to market pricing - be sufficient to lead to the immediate insolvency of the leveraged sector. With all assets in the hands of risk-averse agents, the risk premium increases to more than double its initial level.

In this counterfactual exercise, no attempt is made to calibrate the rescue operations made to save the banks from collapse. The paper by Del Negro et al. (2018), however, offers a 'quantitative evaluation of the Fed's liquidity policies'.

5. Conclusion – and a caveat

The effect that externalities can have on financial stability has been studied by highlighting two specific channels. The first is via balance sheet rules designed for micro-prudential purposes which turn out to amplify shocks common to all agents through the price of assets on their balance sheets. Such a 'pecuniary externality', first analysed by Kiyotaki and Moore (1997), provides a variant of the 'financial accelerator' of Bernanke and Gertler (1989); and is applied to financial intermediaries subject to VaR rules in Shin (2010).

The second channel, driven by problems of creditor coordination, operates when creditor panic impinges on the equity base of financial intermediaries. Diamond and Dybvig (1983) showed that reserve holdings based on the law of large numbers would be unable to cope in those circumstances; and, as early recall of well-judged but illiquid loans could lead to insolvency, policy action by the central banks was recommended to mitigate the effects of creditor panic. Investment banks can face similar problems even when they invest in fully marketable securities as the 'liquidity insurance' seemingly offered by holding saleable assets can disappear in the face of common shocks. For if creditor panic leads to synchronised selling, 'firesales' can lead to insolvency.

Together these externalities can lead to collective insolvency of highly-leveraged Investment Banks in the face of Bad News as to quality of assets on their balance sheets, as summarized in Figure 5 below. Not only will the news lead to a fall in market demand for the assets in question and in their market price, it can lead to the equivalent of a Bank Run: 'If the news is bad enough, investors will pull back from funding banks and other intermediaries, refusing to roll over their short-term funds as they mature.' Bernanke (2018a).

With mark to market accounting – but without official action to supply liquidity or boost equity -- the effect of these adverse factors can lead to immediate insolvency of Investment Banks, as indicated at R in the figure. In which case, prices of risk assets may have to fall a

[17] 'Brunnermeier (2009) has noted that the use of overnight repos became so prevalent that, at its peak, the Wall Street investment banks were rolling over a quarter of their balance sheets every night' (Shin, 2010, p. 156)

good deal further (to E) to induce non-banks to take them up, as the 'counterfactual' calculations indicate.

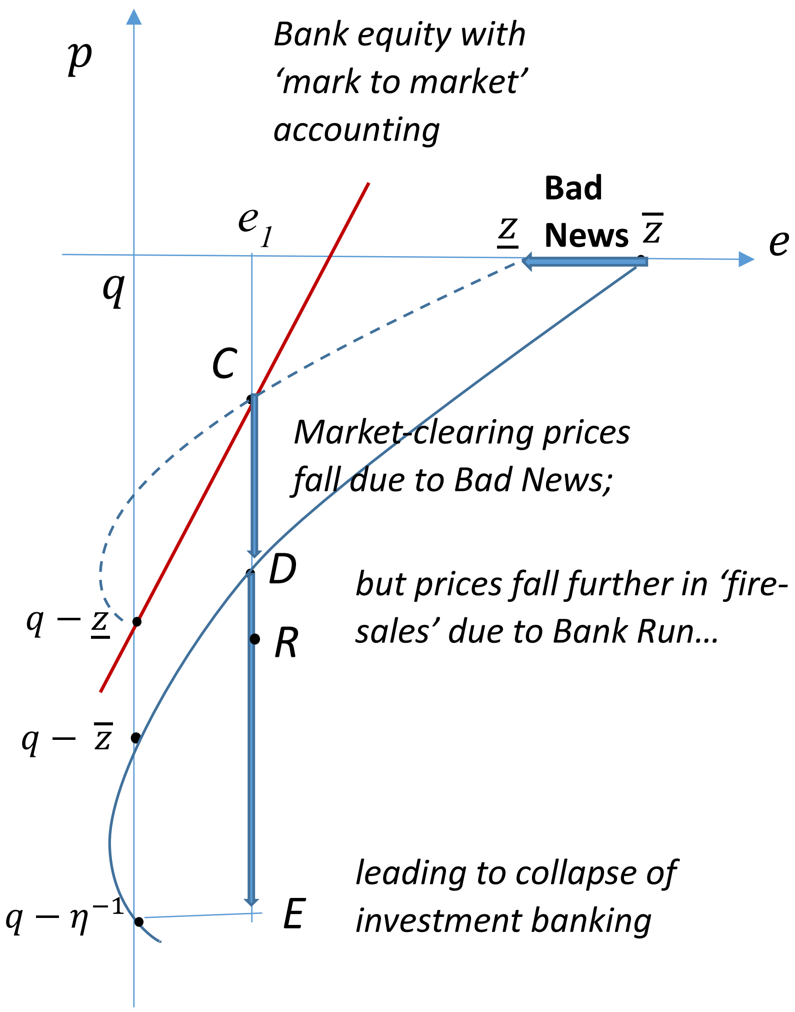


Figure 5 How externalities can lead to financial collapse - a summary

That externalities can play a key role in the financial system has major implications for theory and policy. Theoretically, it challenges unthinking reliance on competitive markets. With private incentives failing to deliver socially efficient levels of public goods, the first welfare theorem of competitive equilibrium will not apply. Public policy, not market forces, will be necessary to protect financial stability. So, in conclusion, we broaden the discussion to look albeit briefly at regulatory, institutional and legal steps taken.

One way of checking externalities is by explicit *Pigovian taxes*. An idea discussed in Brunnermeier et al. (2009) is, for example, that

> bank equity can lowered in a boom by an explicit centralized tax …which has the potential to enhance the efficiency of the overall financial system in the same way as a congestion charge would improve traffic in a city. [Moreover] if the revenue raised

through the Pigovian tax could be put into a separate bank resolution fund, then the scheme would not imply a net transfer away from the banking sector.
Shin (2010, p. 163).

In practice, however, *macro-prudential policy* has been the approach favoured by Central Banks to the reduce systemic risk in banking [18]. Thus, under the provisions of Basel III, capital requirements have been increased and a cyclical buffer added, together with a leverage cap[19]. With regard to liquidity risk, 'Basel III proposals to impose liquidity and stable funding requirements can be thought of as tools to limit the risk of fire sales stemming from bank reliance on short-term debt', De Nicolo et al (2012, p.13).

There has been some *structural change* in banking - with the Volcker Rule to limit proprietary trading by banks in the US and the 'ring-fencing' of banks' of retail banking operations in the UK. New institutions have been created to manage risk. In the U.S. under the provisions of Dodd-Frank Act, a Financial Stability Oversight Council (FSOC) was established as the systemic risk regulator for the United States, with the secretary of the Treasury in the chair and the head of the Fed as a key adviser. In the UK – to complement the Monetary Policy Committee, whose task was, broadly, to protect the public good of price stability - the Bank of England now has a Financial Policy Committee designed 'to remove or reduce systemic risk with a view to protecting and enhancing the resilience of the UK financial system'.

After the Wall Street crash and banking collapse, major public policy intervention - the wide-ranging Glass-Steagall Act of 1933 in particular - restored stability and trust in US banking. Are these varied responses to the recent crisis sufficient to stabilise the business of investment banking; or are further steps needed?

In considering this question, we return to the caveat flagged in the Introduction. For there is ample evidence of successful cheating by banks. Robert McCauley (2019, p.73), for example, points out that 'the application of the international rules known as Basel II allowed big banks to evaluate the riskiness of their assets and permitted US securities firms and European Banks to pile50 or more dollars or euros for every dollar or euro of equity'. It

[18] See, for example, De Nicolo et al (2012) for a 'taxonomy of macro-prudential policies in terms of the specific negative externalities in the financial system that these policies are meant to address'. Walther (2016) considers how capital and liquidity regulations are best combined. Cerutti et al. (2017) provide a review of evidence on the use and effectiveness of macro-prudential policies.

[19] With Systemically Important Financial Institutions (SIFIs) required to hold more and higher-quality capital.

appears that they took advantage of this to 'game' the weights intended to measure the risk on assets in their portfolios - allowing them to take on higher-than-justified leverage [20].

Jon Danielsson (2019, p. 261) explains bluntly:

> There is considerable scope for mistakes, misrepresenting or outright manipulation of the various parts of the capital calculation, and so there is no surprise that banks have become increasingly adept at manipulating the capital ratio, a process called *capital structure arbitrage.* Any bank wanting to be seen as having a high capital [ratio] while actually holding little capital can use clever financial engineering tricks to make bank capital appear to be almost anything the bank wanted, at least until 2008.

There is a raft of legal evidence showing that the riskiness of the assets that investment banks were holding and assembling for sale was substantially understated. American investment banks and affiliates of European banks have been found guilty in US courts for mis-selling securitised mortgages; and the unregulated, but highly regarded, Credit Rating Agencies found guilty of mis-rating as they competed for business[21]. Indeed, Akerlof and Shiller (2015) cite this as a prime example of those with superior information colluding to fool those with less – what they call 'phishing for phools'.

In the approach taken by Gertler and Kiyotaki (2015), the moral hazard problem of the temptation to cheat is solved by self-regulation in the form of substantial equity buffers[22]. For Adrian and Shin, on the other hand, VaR regulations imposed by the BCBS are sufficient to make banks cover the downside risk on their portfolios. The evidence of successful cheating challenges both these perspectives.

Unsolved agency problems do not mean that externalities in the financial system are irrelevant: indeed, they surely imply greater fragility of the banking system. The intellectual challenge is how to combine externalities with 'the economics of manipulation and deception'[23]. Could it be, for example, that the 'good news' shocks we discuss were due to 'inflated ratings' secured by the banks; and the 'bad news' was when the mis-rating came to light?

---

[20] As Haldane et al. (2010, p.89) note: 'Those banks with the highest leverage are also the ones which have subsequently reported the largest write-downs. That suggests banks may also have invested in riskier assets, which regulatory risk weights failed to capture.'

[21] More detail is provided in Miller et al. (2018).

[22] In their numerical example, the self-regulatory buffer is put at 10%; but as Danielsson (2019, Figure 14.2, p. 262) shows, as risk weighted capital ratios moved towards this level, up from 7.5% to over 8% before the crisis, unweighted ratios fell from 3.2% to less than 3%!

[23] The application of Akerlof's lemon's model in this context is discussed by Miller et al. (2018); while Y. Zhang (2017) examines the effect of asymmetric information on equilibria of the Shin model.

References

Adrian T. and & H. S. Shin (2014) "Procyclical Leverage and Value-at-Risk," *Review of Financial Studies*, 27(2), 373-403.

Adrian, T. and H. S. Shin (2011) “Financial Intermediaries and Monetary Economics”. *Handbook of Monetary Economics*, Volume 3A.

Akerlof, G. A. and R. J. Shiller, (2015) *Phishing for Phools: The Economics of Manipulation and Deception.* Princeton, NJ: Princeton University Press.

Allen, F. and D. Gale (2007), *Understanding Financial Crises*. Oxford: Oxford University Press

Allen, F. and D. Gale (2000), “Financial Contagion,” *Journal of Political Economy*, 108 (1), 1–33.

Bernanke, B. (2018a) https://www.brookings.edu/blog/ben-bernanke/2018/09/13/financial-panic-and-credit-disruptions-in-the-2007-09-crisis/

Bernanke, B. (2018b) “The Real Effects of Disrupted Credit” *Brookings Papers in Economic Analysis,* Sep

Bernanke, B., and M. Gertler (1989), " Agency Costs, Net Worth, and Business Fluctuations” , *American Economic Review*, 79 (1), 14-31

Blinder, A. S. (2013) *After the Music Stopped: The Financial Crisis, the Response, and the Work Ahead*. NY, NY: Penguin Group.

Brunnermeier, M. (2009), “De-Ciphering the Credit Crisis of 2007”. *Journal of Economic Perspectives,* 23(1): 77-100.

Cerutti, E.M. & S. Claessens & L. Laeven (2017). "The Use and Effectiveness of Macroprudential Policies; New Evidence," *Journal of Financial Stability*, 28(C), 203-224.

Cochrane, J.H. (2001) *Asset Pricing*. Princeton, NJ: Princeton University Press

Davila, E. and A. Korinek (2017) “Pecuniary Externalities in Economies with Financial Frictions”. *Review of Economic Studies,* 85(1), 352-395.

Danielsson, J. (2019) “Financial Policy After the Crisis”. In *The 2008 Global Financial Crisis in Retrospect,* R. Z.Aliber and G Zoega (eds.), Chapter 14 pp.257- 280. Cham, Switzerland: Palgrave Macmillan

De Nicolo, G., G. Favara and L. Ratnovski (2012). “Externalities and macro-prudential policy”, IMF Staff Discussion Note 12/05.

Del Negro, M., G. Eggertsson, A. Ferrero and N. Kityotaki (2017) “The Great Escape? A quantitative evaluation of the Fed’s liquidity policies”. *American Economic Review*, 107(3) 824-857. March

Diamond, D.W. and P.H. Dybvig, 1983. “Bank Runs, Deposit Insurance, and Liquidity”. *Journal of Political Economy,* 91(3), pp. 401–419.

Financial Crisis Inquiry Commission (2011) *Final Report.* NY, NY: Public Affairs

Gai, P., A. Haldane and S. Kapadia (2011)”Complexity, concentration and contagion”, *Journal of Monetary Economics*, 58(5), 453-470.

Gertler M., N. Kiyotaki and A.Prestipino (2017) “A Macroeconomic model with financial panics.” NBER WP 24126

Gertler, M., N. Kiyotaki and A. Prestipino (2016). “Wholesale Banking and Bank Runs in Macroeconomic Modeling”. In Taylor, J.B., and H. Uhlig. (Eds.), *Handbook of Macroeconomics*. Vol. 2B: 1345-1425. Elsevier, Amsterdam, Netherlands. WP 21892

Gertler, M. and N. Kiyotaki. 2015. “Banking, Liquidity and Bank Runs in an Infinite Horizon Economy”, *American Economic Review*, 105: 2011-2043.

Goodhart, C. (2011) *The Basel Committee on Banking Supervision: a history of the early years 1974-1997*. Cambridge: Cambridge University Press

Haldane, A., S. Brennan and V. Madouros, 2010. “What is the Contribution of the Financial Sector: Miracle or Mirage?”, *The Future of Finance: the LSE report*, Chapter 2. London: LSE.

Kiyotaki, N. and J. Moore (1997), “Credit Cycles”, *Journal of Political Economy*, 105(2), 211-248.

Korinek, A. (2009), “Systemic risk: Amplification Effects, Externalities and Policy Responses.” Working Papers 155, Austrian Central Bank.

Krugman, P. (2018), “Good enough for government work? Macroeconomics since the crisis”, *Oxford Review of Economic Policy*, 34(1-2): 156–168, https://doi.org/10.1093/oxrep/grx052.

McCauley, R.C, (2019), “The 2008 GFC: Savings or Banking Glut?” In *The 2008 Global Financial Crisis in Retrospect,* R. Z.Aliber and G Zoega (eds.), Chapter 5, pp.57-86. Cham, Switzerland: Palgrave Macmillan

Miller, M., S. Rastapana and L. Zhang (2018) “The blind monks and the elephant: contrasting narratives of financial crisis.” *The Manchester School.* 86 (S1): 83–109 September

Shafer, J. R. (2019)”Foreign Capital Flow and Domestic Drivers of the US Financial Crisis and its Spread Globally. ” In *The 2008 Global Financial Crisis in Retrospect,* R. Z.Aliber and G. Zoega (eds.), Chapter 7, pp.111-138. Cham, Switzerland: Palgrave Macmillan

Shin, H.S (2010) *Risk and Liquidity*, Oxford: Oxford University Press

Tooze, A. (2018) *Crashed: How a Decade of Financial Crisis Changed the World.* London: Allen Lane

Walther, A. (2016) “Jointly optimal regulation of bank capital and liquidity”*, Journal of Money, Credit and Banking* 48 (2-3), 415-448.

Zhang, Y. (2017) 'Procyclical-leverage, asymmetric information and financial market instabilities', MSc Dissertation, University of Warwick.

Annex A Involuntary deleveraging (in a systemic bank run) and the threat of insolvency

To analyse how aggregate funding losses reduce investment bank demand for risk assets, we start with the balance sheet of investment banks in aggregate:

$$py = B + e_0$$

where *B* denotes borrowing and *p* is the price of risk assets. Let involuntary deleveraging be introduced as

$$B = (1 - \omega)(q - z)y$$

where the term ω represents the fraction of withdrawals**,** relative to the standard assumption of maximum borrowing consistent with VaR.

To see how this impacts on asset demand we substitute for *B* in the balance sheet:

$$py = (1 - \omega)(q - z)y + e_0$$

hence

$$\big(p - (1 - \omega)(q - z)\big)y = [(p - q + z) + \omega(q - z)]y = e_0$$

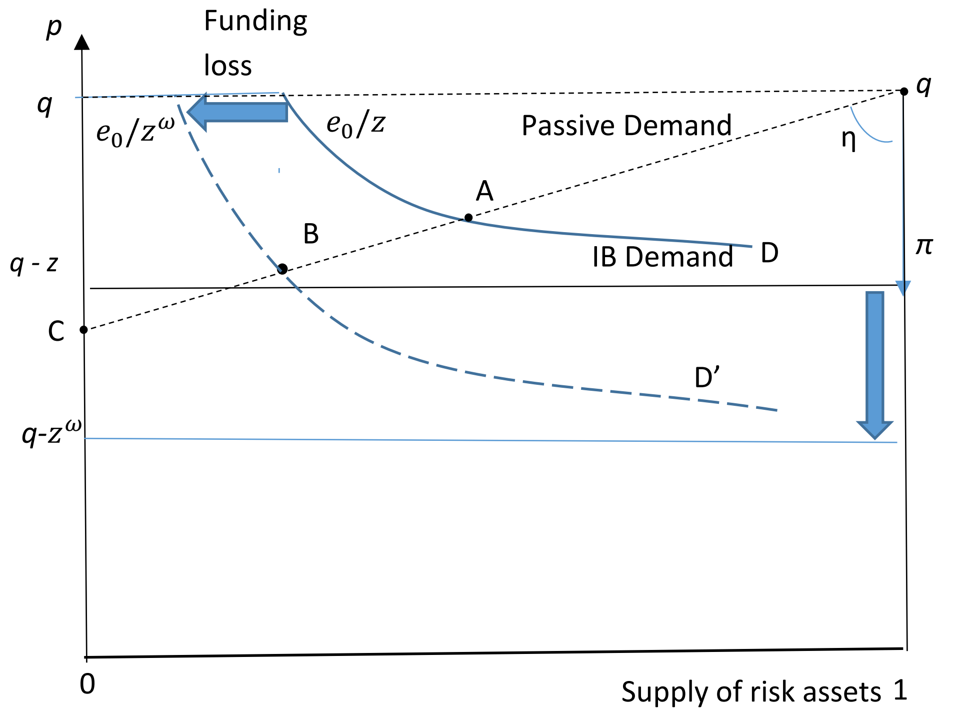
giving the revised demand for risk assets as

$$y = \frac{e_0}{z - \pi + \omega\,(q - z)} = \frac{e_0}{z^{\omega} - \pi}$$

where $z^{\omega} = (1 - \omega)z + \omega\, q > z$.

By reducing assets in line with borrowing for given equity, e_0, it's 'as if' the investment banks are aiming at a higher capital ratio **-** specifically that which would match greater downside risk of $z^{\omega} > z$. Note, however, that the risk aversion of non-banks, as measured by $\eta = 3\tau/z^2$, remains unchanged.

How this reduces investment bank demand for risk assets is shown by the dashed line labelled D' in Figure A1, a modification of the diagram in Shin (2010, p.33). If as shown $\eta^{-1} > z$, asset prices will fall sharply as banks sell to patient investors.



η

Figure A1: Impact effect of systemic Involuntary Deleveraging

In the figure, where market equilibrium shifts from A to B, the reduction of deposits shown by the dashed schedule does not indicate immediate insolvency. This may occur, however, if a greater rate of withdrawals pushes the asset price to $-z$; then the risk premium will jump to $\frac{1}{\eta}$ as all assets are transferred to Passive Investors, as at point C.

Algebraically, the effect of the run will be to revise the schedule determining the market clearing asset price $g(q-p;z)$ as follows. Substituting the revised demand for risk assets, along with the demand by 'patient' investors, into the market clearing condition $y + x = 1$ yields

$$e_0/(z^\omega - \pi) + \eta\pi = 1$$

so

$$e_0 - z^\omega + (1+\eta z^\omega)\pi - \eta\pi^2 = 0$$

giving the revised polynomial

$$g1(q-p;z^\omega) = \eta\pi^2 - (1+\eta z^\omega)\pi + z^\omega = (\eta(q-p)-1)(q-p-z^\omega) = e_0$$

with roots $\eta^{-1}$and z^ω.

Relative to $g(q-p;z)$, withdrawals shift the schedue down to the right as in Figure A2, which illustrates the case where insolvency is immediate, with the fall in the asset price from A to B being sufficient to reduce initial equity to zero. In the main text, however, insolvency occurs because - in addition to 'fire sales' by deleveraging banks - the price of risk assets suffers from the direct impact of bad news on asset quality.

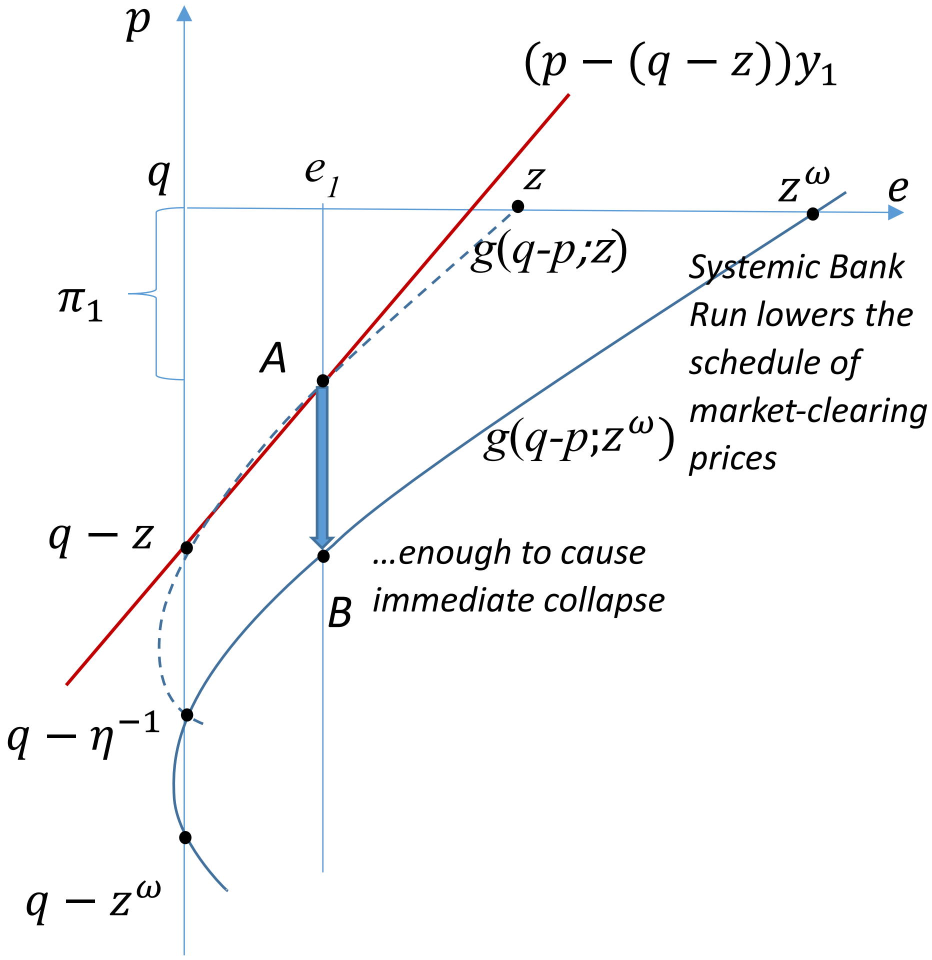


Figure A2 A systemic bank run leading to prompt insolvency for Investment Banks